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FORM PTO-1390 (REV 5-93) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO (If known, see 37 CFR 1.5)
10/018904

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE00/02797	16 August 2000	18 September 1999

TITLE OF INVENTION
ELECTRON-OPTICAL LENS ARRANGEMENT WITH AN AXIS THAT CAN BE LARGELY DISPLACED

APPLICANT(S) FOR DO/EO/US
ROSE, Harald; SCHMID, Peter; JANZEN, Ronald

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371
3. [X] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1)
4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [X] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US)
6. [X] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [X] Other items or information: International Preliminary Examination Report

"Express Mail" mailing label number ET 670106716 US
Date of Deposit December 17, 2001

I hereby certify that this paper is being deposited with the U.S. Postal Service "Express Mail-Post Office to Addressee" service under 37 C.F.R. 1.10 on the date indicated above and is addressed to: Hon. Commissioner of Patents and Trademarks, Washington, D. C. 20231.

Edwin D. Schindler, Reg. No. 31,459

December 17, 2001
Date

10018904 10/018904

17. [X] The following fees are submitted:

	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)): $890.00 Search Report has been prepared by the EPO or JPO..... ~~$830.00~~		
531 Rec'd PCT 17 DEC 2001		
International preliminary examination fee paid to USPTO (37 CFR 1.482) ..... $640.00 No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)).. $710.00 Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37CFR 1.445(a)(2)) paid to USPTO..... $950.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4)..... $90.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00	
Surcharge of $130.00 for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ -0-	

Claims	Number Filed	Number Extra	Rate		
Total 12 Claims	12 -20 =	-0-	X $22.00	$ -0-	
Independent Claims	1 -3 =	-0-	X $74.00	$ -0-	
Multiple dependent claims(s) (if applicable)			+ $230.00	$ -0-	
TOTAL OF ABOVE CALCULATIONS =				$ 890.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$ -0-	
SUBTOTAL =				$ 890.00	
Processing fee of $130.00 for furnishing the English translation later the [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).			+	$ -0-	
TOTAL NATIONAL FEE =				$ 890.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$ -0-	
TOTAL FEES ENCLOSED =				$ 890.00	
				Amount to be: refunded	$
				charged	$

a. [X] A check in the amount of $**890.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. _____ in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 19-0450. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Edwin D. Schindler
Five Hirsch Avenue
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Coram, New York 11727-0966

SIGNATURE

Edwin D. Schindler
NAME

31,459
REGISTRATION NUMBER

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANTS: HARALD ROSE ET AL. ART UNIT:

SERIAL NO.: 09/ EXAMINER:

FILED:

P.C.T. APPLICATION NO.: PCT/DE00/02797

P.C.T. INTERNATIONAL FILING DATE: AUGUST 16, 2000

PRIORITY CLAIMED: SEPTEMBER 18, 1999

TITLE: ELECTRON-OPTICAL LENS ARRANGEMENT WITH AN AXIS THAT CAN BE LARGELY DISPLACED

PRELIMINARY AMENDMENT

Hon. Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D. C. 20231

Dear Sir:

Prior to an examination on the merits of the above-identified patent application, please amend the English translation of the above-identified application as follows:

IN THE ABSTRACT OF THE DISCLOSURE

Please use the accompanying Abstract of the Disclosure,

"Express Mail" mailing label number ET 670106716 US
Date of Deposit December 17, 2001

I hereby certify that this paper is being deposited with the U.S. Postal Service "Express Mail - Post Office to Addressee" service under 37 C.F.R. §1.10 on the date indicated above and is addressed to: Hon. Commissioner for Patents, United States Patent and Trademark Office, Washington, D. C. 20231.

Edwin D. Schindler, Reg. No. 31,459

December 17, 2001
Date

which is contained on a separate sheet of paper, as required by 37 C.F.R. §1.72(b), as the Abstract for the instant patent application.

IN THE SPECIFICATION

Please amend the Specification, which is the literal English translation of the P.C.T. application filed on August 16, 2000:

Page 1, between lines 3-4 (immediately beneath the Title of the Invention), insert the following headings:

--BACKGROUND OF THE INVENTION--; and,

--Technical Field of the Invention--.

Page 1, between lines 12-13, insert the following heading:

--Description of the Prior Art--

Page 3, between lines 22-23, insert the following heading:

--SUMMARY OF THE INVENTION--.

Page 10, line 18, insert the following:

--BRIEF DESCRIPTION OF THE DRAWING FIGURE--

Page 10, between lines 3-4, insert the following heading:

--DETAILED DESCRIPTION OF THE DRAWING FIGURE AND PREFERRED EMBODIMENTS--.

IN THE CLAIMS

Please cancel Claims 1-9 (as presented in the literal English translation of P.C.T. Application No. PCT/DE00/02797) and substitute the following claims therefor:

--10. An electron-optical lens arrangement with an axis capable of being substantially displaced, comprising:

a cylinder lens;

electrodes or pole shoes for generating a quadrupole field, said quadrupole field having a plane of symmetry extending in a mid-plane of a gap pertaining to said cylinder lens, said electrodes or said pole shoes being provided in a direction of said gap pertaining to said cylinder lens and being individually excitable;

a focussing plane of said quadrupole field being aligned in the direction of said gap, with a magnitude of focussing refractive power of said cylinder lens being twice as high as that of said quadrupole field;

a deflection system for charged particles being connected downstream in the plane of said gap pertaining to said cylinder lens, said quadrupole field being displaceable according to deflection of a particle beam, so that the particle beam impinges in an area of said quadrupole field; and,

means for holding an object, said means for holding being displaceable perpendicularly relative to an optical axis of, and relative to the direction of said gap pertaining to, said cylinder lens.

11. The electron-optical lens arrangement with an axis capable of being substantially displaced according to Claim 10, wherein said electrodes or pole shoes are both individually and successively excitable.

12. The electron-optical lens arrangement with an axis capable of being substantially displaced according to Claim 10, wherein said cylinder lens is electrical.

13. The electron-optical lens arrangement with an axis capable of being substantially displaced according to Claim 10, wherein said quadrupole field is electrical.

14. The electron-optical lens arrangement with an axis capable of being substantially displaced according to Claim 10, wherein said cylinder lens includes a center electrode, which is subdivided in the direction of the gap into individual regions which are electrically insulated from one another and individually actuatable.

15. The electron-optical lens arrangement with an axis capable of being substantially displaced according to Claim 14, wherein said center electrode of said cylinder lens is comb-shaped.

16. The electron-optical lens arrangement with an axis capable of being substantially displaced according to Claim 10, wherein electrical fields or magnetic fields extend symmetrically relative to a center plane of said cylinder lens.

17. The electron-optical lens arrangement with an axis capable of being substantially displaced according to Claim 10, wherein a plurality of said electron-optical lens arrangements are positioned adjacent to one another and contiguous to one another in the direction of the gap pertaining to the cylinder lens.

18. The electron-optical lens arrangement with an axis capable of being substantially displaced according to Claim 10, wherein a plurality of said electron-optical lens arrangements are positioned vertically one above another relative to the direction of the gap.

19. The electron-optical lens arrangement with an axis capable of being substantially displaced according to Claim 10, wherein said deflection system comprises a first element and a second element with said first element arranged beyond said second element in the direction of the particle beam, said first element and said second element deflect, in opposite directions for producing a paraxial beam deflection.

20. The electron-optical lens arrangement with an axis capable of being substantially displaced according to Claim 10, wherein said deflection system comprises a first magnetic field, being a static magnetic field, and a second magnetic field, and is connected upstream in a direction of ray impingement and is variable with respect to time.

21. The electron-optical lens arrangement with an axis capable of being substantially displaced according to Claim 20, wherein said static magnetic field has a pole shoe, with the form of said pole shoe being chosen so that, independent of deflection, an emerging particle stream travels parallel to an incident particle stream.--

REMARKS

Prior to an examination on the merits of the above-identified patent application, please enter the foregoing amendments.

Claims 10-21 are now pending in the above-identified patent application, as presented by the instant Preliminary Amendment. Claim 10 is the single claim presented in independent form.

The present application represents the U.S. National Phase of P.C.T. Application No. PCT/DE00/02797, filed August 16, 2000, and claiming foreign priority on the basis of a corresponding Federal Republic of Germany patent application, filed September 18, 1999.

The claims being entered via the present Preliminary Amendment are intended to substitute for Claims 1-9 of the P.C.T. international application. An English translation of the P.C.T. international application is being concurrently filed.

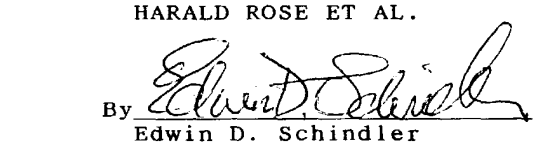
New Claims 10-21, which have been drafted in conformance with U.S. claim practice. Various formal amendments have also been entered to the Specification, and an Abstract for the application, on a separate sheet of paper, is enclosed.

The application is now in condition for a full examination on the merits.

Accordingly, an early examination on the merits and allowance are, therefore, respectfully requested and earnestly solicited.

Respectfully submitted,

HARALD ROSE ET AL.

By 

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December 15, 2001

ABSTRACT OF THE DISCLOSURE

An electron-optical lens arrangement with an axis that can be substantially displaced, and useful for electron lithography, includes a cylinder lens and a quadrupole field. The plane of symmetry of the quadrupole field extends in the mid-plane of the gap pertaining to the cylinder lens. The focussing level of the quadrupole is oriented in the direction of the gap. The amount of the focussing refractive power belonging to the cylinder lens is twice as high as the amount of the quadrupole. A deflection system for the charged particles is connected upstream in the level of the gap pertaining to the cylinder lens and several electrodes or pole shoes, which generate a quadrupole field are provided in the direction of the gap pertaining to the cylinder lens. The electrodes or pole shoes can be individually and, preferably, successively excited and the quadrupole field can be displaced according to the deflection of the particle beam, so that the particle beam impinges upon the area of the quadrupole field. A holding device is provided for an object, such as a wafer, and is arranged vertically in relation to the optical axis and can be displaced in relation to the direction of the gap pertaining to the cylinder lens.

2/PRTS

Electron-Optical Lens Arrangement with an Axis that Can be Largely Displaced

The invention relates to an electron-optical lens arrangement with an axis that can be largely displaced, especially for electron lithography, with a cylinder lens and a quadrupole field, the plane of symmetry of said quadrupole field extending in the mid-plane of the gap pertaining to the cylinder lens, the focussing plane of the quadrupole being aligned in the direction of the gap, and the magnitude of the focussing refractive power belonging to the cylinder lens being twice as high as that of the quadrupole.

One of the main fields of application of electron beam lithography is the production of electronic components and integrated circuits on the surface of disc-shaped semiconductor crystals (wafers). Their desired miniaturisation requires the writing of structures of the smallest possible size. The decisive advantage over optical lithography consists in the fact that the wavelengths of the electrons are much smaller that those of light, and therefore allow the reproduction of smaller structures. Furthermore, electron-beam writers have the capability of recording very small structures, but compared with light-optical projects have the disadvantage of a longer exposure time and of the requirements for production of a good vacuum and for a table that can be rapidly and precisely moved in the image plane; this demand results from the fact that known electron-optical deflection elements are only capable of error-free deflection of the beam within the

millimetre range. For this reason, electron-beam lithography has until now been used primarily for the production of masks for optical lithography and for the production of custom chips, in which the required time is of secondary importance.

Goto and Somo, published in the journal "Optik" 48, 255-270 MOL (moving object lense), 1977, proposed overlaying the circular lens field with deflection fields, by means of which the image field can be enlarged, which is not sufficient to obtain an image field of the extent of a wafer, so that the bore diameter of the circular lens still decisively limits the useable image field. In addition, a workpiece holding device that is movable two-dimensionally in a plane perpendicular to the electron beam is required, with the efficiency of the system and the minimum size of the structures that can be generated depending on the accuracy of movement of this holding device; and the speed of movement of the holding device determining the maximum writing speed.

For focussing of charged particles, cylinder lenses have been disclosed (H. Rose, Optik 36, 1971, pages 19 to 36), in which the electrodes or pole shoe have a gap-shaped opening which serves to generate the electrical or magnetic field respectively, and whose longitudinal axis is aligned perpendicular to the optical axis, this longitudinal axis, together with the optical axis, spanning a plane which describes the mid-plane of the cylinder lens arrangement. A stigmatic imaging by means of the cylinder lenses is in principal impossible, since a focussing effect

only takes place perpendicular to the gap direction, the movement components of the charged particles to be represented, by contrast, undergoing no deflection parallel to the gap (or vice versa). The rod-shaped astigmatic point images obtained are unsuitable for imaging. PCT/DE 97/05518 discloses an electron-optical lens arrangement, in which the cylinder lens overlays a quadrupole field and is assigned in such a way that the focussing plane of the quadrupole is aligned in the direction of the gap pertaining to the cylinder lens and consequently the defocussing plane extends perpendicular to this, with coaxial optical axes. As a result, the focussing takes place in one of the gap planes by means of the quadrupole field and in the plane extending perpendicular thereto by means of the cylinder lens, whose intensity is to be adjusted such that an elimination of the defocussing component of the quadrupole field occurs. If the focussing effect in the two planes extending perpendicular to one another is adjusted in an identical manner, the combination of the two lenses results in stigmatic images.

On this basis, the object of the invention is to provide an electron-optical lens arrangement which has a very wide operating range in one direction and the beam can also be made to impinge essentially always perpendicularly on the object even in regions distant from the centre.

This object is solved according to the invention in that a deflection system for the charged particles is

connected upstream in the plane of the gap pertaining to the cylinder lens, and

- a plurality of electrodes or pole shoes are provided in the direction of the gap pertaining to the cylinder lens, which generate a quadrupole field and can be individually and preferably successively excited, and
- the quadrupole field is displaced corresponding to the deflection of the particle beam such that the particle beam impinges in the area of the quadrupole field, and
- a holding device for the object is provided, which can be displaced perpendicularly to the optical axis and to the direction of the gap pertaining to the cylinder lens.

The gist of the invention consists in connecting a deflection system upstream of the electron-optical lens arrangement, the deflection system consisting of a cylinder lens and quadrupole field and displacing the particle beam, which generally consists of electrons, essentially paraxially and in the direction of the gap pertaining to the cylinder lens, and the quadrupole field being generated in the impingement point of the particle beam within the lens arrangement. The spatial displacement of the quadrupole field is carried out by electronic means, i.e. the quadrupole field is excited in the region of the impingement point of the particle beam by actuation of the electrodes (in the case of electrical lenses) or pole shoes (in the case of magnetic lenses) that are located there. For the

specific constructional implementation, basically two principles are conceivable: on the one hand the quadrupole field can be displaced discontinuously in the direction of the gap pertaining to the cylinder lens, so that with continuous displacement of the particle beam, the latter generally passes through the lens arrangement, for example outside the axis of the quadrupole field. These slight deviations from the axis of the quadrupole field are the cause of the occurrence of electron-optical image errors, which, however, because of the low deviations, are so small that they cannot significantly affect the quality of the optical representation. In addition, arrangements are also conceivable in which, synchronously with the deflection of the particle beam and therefore continuously, the quadrupole field is displaced in the direction of the gap pertaining to the cylinder lens. By a corresponding adjustment, it can be achieved that the particle beam extends exactly in the axis of the quadrupole field, so that the occurrence of image fields by virtue of the extra-axial passage of the particle beam generated by the quadrupole field is suppressed. By virtue of the fact that the generation of the quadrupole field is provided by the constructional arrangement of the electrodes or pole shoes, which require their own space and consequently are of finite extension in the direction of the gap pertaining to the cylinder lens, it is theoretically desirable to displace the quadrupole field in infinitesimally small steps, but in practice this can only be approximated. The particle beam in the proposed arrangement will also

impinge on the object essentially perpendicularly and with unchanged optical image quality, even in regions distant from the object centre. It is thus possible, without quality loss, to displace the particle beam over a range delimited by the width of the gap pertaining to the cylinder lens. The result is that an exact optical reproduction along a straight line extending in the direction of the gap pertaining to the cylinder lens can be carried out. The restriction of the image field caused by the bore of the circular lenses is eliminated.

Compared with the former electron-lithography arrangements for writing on the object, in which two-dimensional displacement perpendicular to the electron beam by mechanical means was indispensable, which inevitably resulted in a considerable restriction of the effectiveness, the object can now be displaced also in a direction perpendicular to the gap pertaining to the cylinder lens, but still in a plane perpendicular to the optical axis and consequently still only one-dimensionally. A one-dimensional displacement also at low speed allows much more precise operation.

Use is essentially in a manner known per se, in that the object, which in the case of electron lithography, will often be a semiconductor wafer, is fixed so as to be mechanically displaceable one dimensionally, perpendicular to the optical axis and also to the gap pertaining to the cylinder lens. Perpendicular to this, the writing by the particle beam is carried out by means of the aforementioned

electron-optical lens arrangement in a very long linear range, which extends in the direction of the gap pertaining to the cylinder lens, and along which a good stigmatic representation of all points is possible. With the above-described arrangement, with a resolution of 0.025 micrometres and an axial spacing of 5 mm, a distortion-free image can be produced. As a result, a significant enlargement of the linearly reproduced region of high optical quality, which extends in the direction of the gap pertaining to the cylinder lens is obtained. Perpendicular to this, i.e. in the displacement direction of the object, the image quality will be further determined by the displacement accuracy of the mechanical system, though it should be pointed out that the one-dimensionality and slower displacement permits substantially more precise operation of the mechanical system.

Within the scope of the invention, it is in principle immaterial whether the quadrupole field and/or cylindrical field is generated electronically or magnetically. It has been recognised as expedient to choose the cylindrical field and/or in particular the quadrupole field to be displaced electrically, because then, with the avoidance of remanences and eddy currents, rapid field displacement is possible.

For the specific embodiment of the electrical quadrupole field, which is displaceable in the direction of the gap pertaining to the cylinder lens, the centre electrode of the cylinder lens is subdivided in the direction of the gap into mutually

electrically isolated individual electrodes, which are individually actuatable. For displacement and for generation of the desired electrical field, the individual electrodes are successively subjected to the appropriate voltage. The successive actuation of adjacent electrodes provides the desired displacement.

For the reduction of many of the second-order image errors caused by the curved optical axis, it is preferred to choose the fields and the resulting fundamental paths so as to be symmetrical to the mid axis of the lens.

Hitherto described was an arrangement in which a single source (electron source) generates the particle beam for writing on the object and deflects it in the above-described manner. A significant enlargement of the image field in the direction of the straight line providing error-free imaging and extending in the direction of the gap pertaining to the cylinder lens can be achieved in that a plurality of the above-described arrangements are arranged parallel to one another and adjacent to one another in the direction of the gap pertaining to the cylinder lens, in the manner that the image range of adjacent arrangements overlap or are at least contiguous to one another. In the case of n similar arrangements, an n-fold image width can be obtained. Because of the possibility of synchronous operation of each individual arrangement, there remains the writing duration required by an individual arrangement.

Another possibility for reducing the writing duration can be achieved by the fact that a multiplicity of the above-described arrangements are arranged perpendicular to the direction of the gap, and thereby one above the other. By this means it is achieved that the object is written on simultaneously in a multiplicity of regions lying one behind the other in the direction of movement of the object, so that one particle beam only has to cover a single partial range. The displacement of the object must only take place such that the beam only covers the range assigned to it.

The deflection systems acting in the gap plane of the cylinder lens and connected upstream thereof should ensure, as far as possible, perpendicular impingement on the object, that is to say the particle beam should be displaced in a paraxial manner. For this reason, it is advisable to construct the deflection system from two elements, which are arranged one behind the other in the direction of the particle beam and deflect in two opposing directions, that is to say the beam is deflected away from the optical axis in the first element and in the second element oriented in a paraxial direction. In this case, the spatial arrangement of the elements with respect to one another and with respect to the cylinder lens is in principle immaterial. A simple constructional implementation could consist in arranging the second element in the entrance region of the cylinder lens by mounting a dipole. It is important with different deflections to ensure the paraxiality of the beam. In

the most general case, the question of the implementation of the deflection, be it by electrical or magnetic fields, is in principle immaterial.

As regards the deflection system connected upstream of the lens arrangement, a preferred embodiment is one in which, in addition to a static magnetic field, a second magnetic field, varied with respect to time, and connected upstream of the beam path, is provided. By virtue of different application of the latter magnetic field, the particle beam is displaced so as to be paraxial in the direction of the gap pertaining to the cylinder lens.

It is advantageous to choose the form of the pole shoe of the magnetic field such that, irrespective of the deflection of the emerging particle stream by the upstream-connected magnetic field, paraxiality to the impinging particle stream is always produced.

Further details, advantages and features of the invention can be taken from the following descriptive part, which describes a typical embodiment of the invention in greater detail with reference to the drawings, wherein

Figure 1 shows a schematic view of the block circuit diagram of the lens arrangement according to the invention

Figure 2 shows n arrangements adjacent to one another in the direction of the gap of cylinder lens.

The lens arrangement shown in Figure 1 can be subdivided into three regions according to its basic construction:

The particle stream proceeds from elements which generate the charged particles, e.g. the electrons - this takes place in element 1 - and then focuses them to produce a beam (element 2). Herein, the optical axis (3) showing a curved path is shown by a dot-dash line.

The region of particle generation is followed by the deflection, which, in the direction of the beam path, comprises a first magnetic field (4) and a second magnetic field (5) contiguous to the first, a different deflection being generated by variation of the magnetic field intensity and an essentially paraxial alignment of the particle beam being produced by the other, static magnetic field (5). As a result, by virtue of the deflection system (4, 5), an adjustable paraxial offset, which is adjustable in its distance from the mid-axis, is produced. The actual imaging takes place in the last region, which is constructed of a cylinder lens (6) with a centre electrode (7) designed as a comb-shaped lens. By successive application of a voltage of appropriate magnitude to the individual electrodes, a quadrupole field can be generated at different points. The actuation must take place in such a way that a

quadrupole field is excited in the incident point of the particle beam with such an intensity that focussing of the plane extending in the direction of the gap to the image point occurs, and in the plane extending perpendicular to this focussing on the same image point also takes place by virtue of the overlaying of the field of cylinder lens and quadrupole and appropriate adjustment of the cylindrical field, so that stigmatic imaging takes place. By successive deflection of the particle stream and corresponding displacement of the quadrupole field, stigmatic imaging is possible in a straight line extending over the entire width of the gap. To obtain planar writing on the object (9) designated "wafer", this must be displaced in a plane extending perpendicular to the optical axis, specifically perpendicular to the direction of the gap. In comparison to the state of the art, one-dimensional and relatively slow displacement of the object is now necessary.

Figure 2 shows a lens arrangement with three devices of the above described type arranged parallel to one another. Three bundles (3a, 3b, 3c) are drawn, which are displaced in the direction of the gap pertaining to the cylinder lens by a deflector system (4, 5), which is characterised as a capacitor. Herein, the fields are contiguous. The cylinder lens (6) consists of a comb-shaped centre electrode (7) which are charged successively and individually to generate quadrupole fields. In contrast to the arrangement described in Figure 1, the particle stream is

inclined slightly with respect to the optical axis through the cylinder lens arrangement. In a known manner, the particle stream then impinges on the object (9) designated "wafer". As a result, a writable image field is produced, which with n arrangements results in an image field which corresponds to n times the scanning region of a single lens arrangement. The result is a further enlargement of the image field in the direction of the gap pertaining to the cylinder lens.

PATENT CLAIMS

1. Electron-optical lens arrangement with an axis that can be largely displaced, especially for electron lithography, with a cylinder lens and a quadrupole field, the plane of symmetry of said quadrupole field extending in the mid-plane of the gap pertaining to the cylinder lens, the focussing plane of the quadrupole being aligned in the direction of the gap, and the magnitude of the focussing refractive power belonging to the cylinder lens being twice as high as that of the quadrupole, **characterised in that**

- a deflection system (4, 5) for the charged particles being connected downstream in the plane of the gap pertaining to the cylinder lens, and
- said electrodes or pole shoes, which generate a quadrupole field, being provided in the direction of the gap pertaining to the cylinder lens, and being individually and preferably successively excitable, and
- the quadrupole field can be displaced according to the deflection of the particle beam such that the particle beam impinges in the area of the quadrupole field, and
- a holding device is provided for the object, which device can be displaced perpendicularly in relation to the optical axis and in relation to the direction of the gap pertaining to the cylinder lens (6).

2. Lens arrangement according to claim 1, **characterised in that** the cylinder (6) and/or quadrupole field are electrical.

3. Lens arrangement according to claim 1 or 2, **characterised in that** the centre electrode (7) of the cylinder lens (6) is subdivided in the direction of the gap into individual regions which are electrically insulated from one another and individually actuatable (comb-shaped lens).

4. Lens arrangement according to one of the preceding claims, **characterised in that** the fields extend symmetrically with respect to the centre plane of the lens.

5. Lens arrangement according to one of the preceding claims, **characterised by** a multiplicity arrangements adjacent to one another and contiguous to one another in the direction of the gap pertaining to the cylinder lens (6)

6. Lens arrangement according to one of the preceding claims, **characterised by** a multiplicity arrangements vertically one above the other with respect to the direction of the gap.

7. Lens arrangement according to one of the preceding claims, **characterised in that** the deflection system consists of two elements, which are arranged one behind the other in the direction of the particle beam and deflect in opposite directions and by means of which a paraxial beam deflection is achieved.

8. Lens arrangement according to one of the preceding claims, **characterised in that** the deflection system (4,5) is constructed of a static magnetic (5) field and a second magnetic field (4) which connected upstream in the direction of the ray impingement and is variable with respect to time.

9. Lens arrangement according to claim 8, **characterised in that** the form of the pole shoe of the static magnetic field (5) is chosen such that, independent of the deflection, the emerging particle stream travels parallel to the incident particle stream.

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro

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(30) Angaben zur Priorität:
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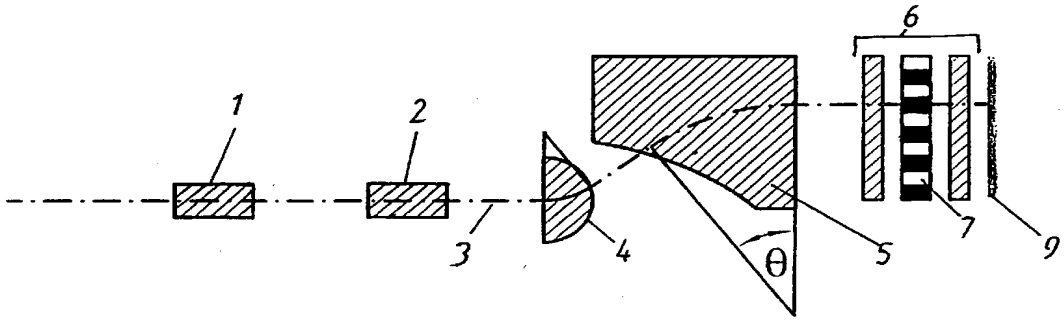
(81) Bestimmungsstaaten *(national)*: JP, KR, US.

[Fortsetzung auf der nächsten Seite]

(54) Title: ELECTRON-OPTICAL LENS ARRANGEMENT WITH AN AXIS THAT CAN BE LARGELY DISPLACED

(54) Bezeichnung: ELEKTRONENOPTISCHE LINSENANORDNUNG MIT WEIT VERSCHIEBBAR ACHSE



(57) Abstract: The invention relates to an electron-optical lens arrangement with an axis that can be largely displaced, especially for electron lithography. The inventive arrangement comprises a cylinder lens and a quadrupole field. The plane of symmetry of said quadrupole field extends in the mid-plane of the gap pertaining to the cylinder lens. The focussing level of the quadrupole is oriented in the direction of the gap. The amount of the focussing refractive power belonging to the cylinder lens is twice as high as the amount of the quadrupole. A deflection system for the charged particles is connected upstream in the level of the gap pertaining to the cylinder lens and several electrodes or pole shoes which generate a quadrupole field are provided in the direction of the gap pertaining to the cylinder lens. Said electrodes or pole shoes can be individually and preferably successively excited and the quadrupole field can be displaced according to the deflection of the particle beam in such a way that the particle beam impinges upon the area of the quadrupole field. A holding device is provided for the object. Said device is arranged vertical in relation to the optical axis and can be displaced in relation to the direction of the gap pertaining to the cylinder lens.

(57) Zusammenfassung: Die Erfindung betrifft eine elektronenoptische Linsenanordnung mit weit verschiebbarer Achse, insbesondere für die Elektronenlithographie, mit einer Zylinderlinse und einem Quadrupolfeld, dessen Symmetrieebene in der Mittelebene des Spaltes der Zylinderlinse verläuft, wobei die fokussierende Ebene des Quadrupols in Richtung des Spaltes ausgerichtet ist und die fokussierende Brechkraft der Zylinderlinse betragsmäßig doppelt so groß wie die des Quadrupols ist, wobei ein Ablenksystem für die geladenen Teilchen in der Ebene des Spaltes der Zylinderlinse vorgeschaltet ist und in Richtung des Spaltes der Zylinderlinse mehrere, ein Quadrupolfeld erzeugende Elektroden bzw. Polschuhe vorhanden sind, die individuell und vorzugsweise sukzessive erregbar sind und das Quadrupolfeld

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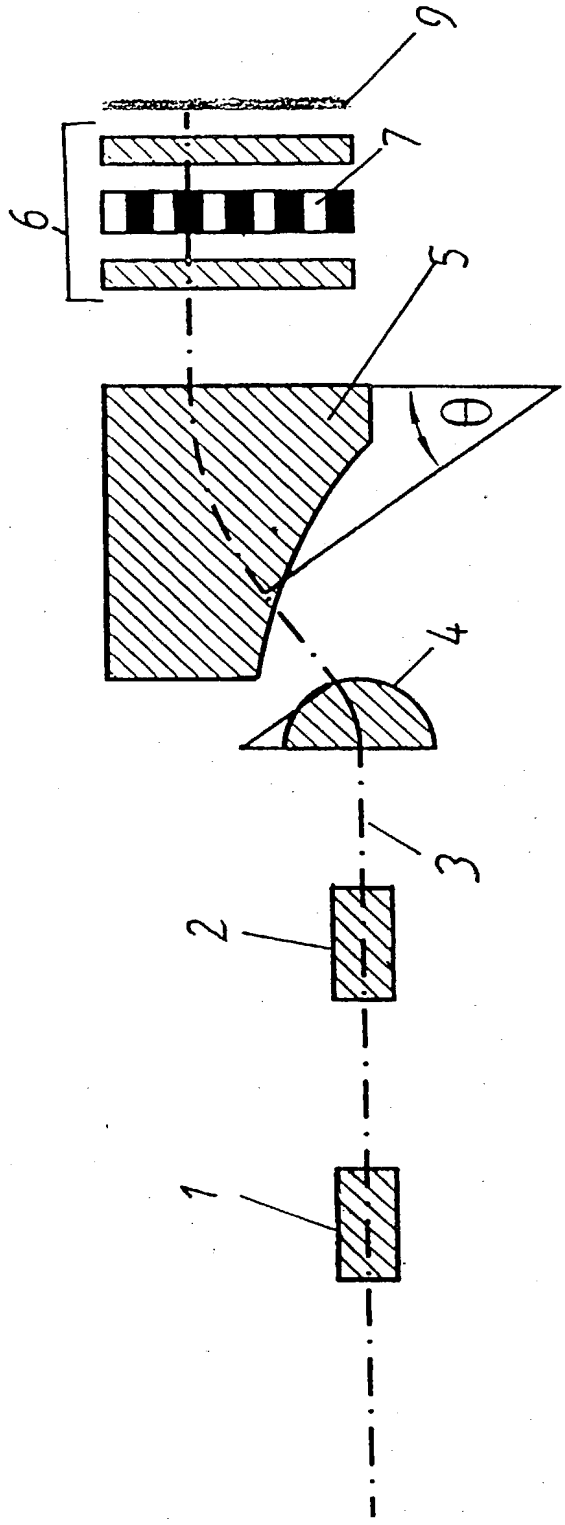

Fig. 1

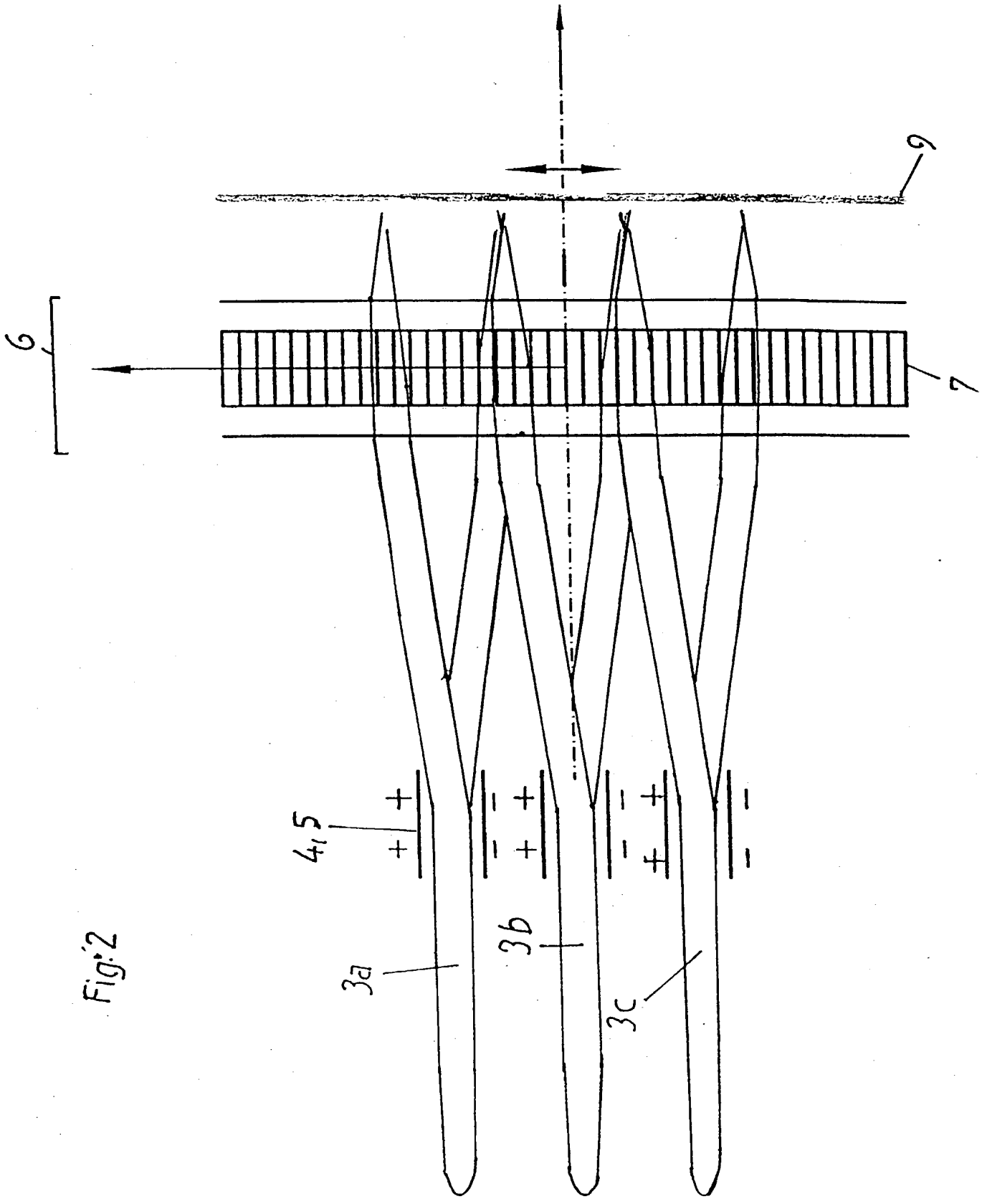

Fig. 2

Declaration and Power of Attorney For Patent Application
Erklärung Für Patentanmeldungen Mit Vollmacht
German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

As a below named inventor, I hereby declare that:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

My residence, post office address and citizenship are as stated below next to my name,

dass ich, nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel:

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Elektronenoptische Linsenanordnung mit weit verschiebbarer Achse

Electron-Optical lens arrangement with an axis that can be largely displaced

deren Beschreibung

(zutreffendes ankreuzen)

☐ hier beigefügt ist.

☒ am 16.08.2000 unter der

Anmeldungsseriennummer PCT/DE 00/02797

eingereicht wurde und am _____ abgeändert wurde (falls tatsächlich abgeändert).

the specification of which

(check one)

☐ is attached hereto.

☒ was filed on August 16, 2000 as

Application Serial No. _____

and was amended on _____ (if applicable)

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

German Language Declaration

Prior foreign applications
Priorität beansprucht

(Number) (Nummer)	(Country) (Land)	(Day/Month/Year Filed) (Tag/Monat/Jahr eingereicht)	Priority Claimed Yes Ja	No Nein
19944857.4	Germany	September 18, 1999	[X]	[ ]
			[ ]	[ ]
			[ ]	[ ]

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 112 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.) (Anmeldeseriennummer)	(Filing Date) (Anmeldedatum)	(Status) (patentiert, anhängig, aufgegeben)	(Status) (patented, pending, abandoned)

Ich erkläre hiermit, dass alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und dass ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, dass wissentlich und vorsätzlich falsche Angaben gemäss Paragraph 1001, Absatz 18 der Zivilprozessordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden koennen, und dass derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

German Language Declaration

VERTRETUNGSVOLLMACHT: Als benannter Erfinder beauftrage ich hiermit den nachstehend benannten Patentanwalt (oder die nachstehend benannten Patentanwälte) und/oder Patent-Agenten mit der Verfolgung der vorliegenden Patentanmeldung sowie mit der Abwicklung aller damit verbundenen Geschäfte vor dem Patent-und Warenzeichenamt: *(Name und Registrationsnummer anführen)*

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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Coram, New York 11727-0966

Send Correspondence to:

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Unterschrift des Erfinders X Harald Rose Datum 6.12.01	Inventor's signature X Date
Wohnsitz Darmstadt, Fed. Rep. of Germany DE	Residence Darmstadt, Fed. Rep. of Germany
Staatsangehörigkeit german	Citizenship german
Postanschrift Prinz-Christians-Weg 5a D-64287 Darmstadt	Post Office Address Hochschulstraße 6 D-64289 Darmstadt
Voller Name des zweiten Miterfinders (falls zutreffend) Peter Schmid	Full name of second joint inventor, if any
Unterschrift des Erfinders X Datum	Second Inventor's signature Date
Wohnsitz Darmstadt, Fed. Rep. of Germany DE	Residence
Staatsangehörigkeit german	Citizenship
Postanschrift Hochschulstraße 6 D-64289 Darmstadt	Post Office Address

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors.)

German Language Declaration

VERTRETUNGSVOLLMACHT: Als benannter Erfinder beauftrage ich hiermit den nachstehend benannten Patentanwalt (oder die nachstehend benannten Patentanwälte) und/oder Patent-Agenten mit der Verfolgung der vorliegenden Patentanmeldung sowie mit der Abwicklung aller damit verbundenen Geschäfte vor dem Patent-und Warenzeichenamt: *(Name und Registrationsnummer anführen)*

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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Coram, New York 11727-0966

Send Correspondence to:

Voller Name des einzigen oder ursprünglichen Erfinders: Prof. Dr. Harald Rose	Full name of sole or first inventor Dr. Roland Janzen
Unterschrift des Erfinders Datum X	Inventor's signature Date X Dr. Roland Janzen 5.12.01
Wohnsitz Darmstadt, Fed. Rep. of Germany	Residence Darmstadt, Fed. Rep. of Germany
Staatsangehörigkeit german	Citizenship german
Postanschrift Prinz-Christians-Weg 5a D-64287 Darmstadt	Post Office Address Hochschulstraße 6 D-64289 Darmstadt
Voller Name des zweiten Miterfinders (falls zutreffend) Peter Schmid	Full name of second joint inventor, if any
Unterschrift des Erfinders Datum X Peter Schmid	Second Inventor's signature Date
Wohnsitz Darmstadt, Fed. Rep. of Germany	Residence
Staatsangehörigkeit german	Citizenship
Postanschrift Hochschulstraße 6 D-64289 Darmstadt	Post Office Address

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors.)

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

Applicant: Prof. Dr. Harald Rose et al.

Name of Party in Interest:

Serial No: 10/018,904 Group Art Unit:

Filed: Concurrently Herewith Examiner:

For: ELECTRON-OPTICAL LENS ARRANGEMENT WITH AN AXIS THAT CAN BE LARGELY DISPLACED

CLAIM FOR SMALL ENTITY STATUS

37 CFR 1.9(c) - INDEPENDENT INVENTOR

I Prof. D. Harald Rose[a] declare and say that:

1) I am ~~the sole~~[b]/a joint inventor[b] named in the above-identified application for Letters Patent.

2) I have not assigned, granted, conveyed, or licensed, and am under no obligation under contract or law to assign, grant, convey, or license, any rights in the invention to any person who could not likewise be classified as an independent inventor if that person had made the invention, or to any concern which would not qualify as a small business concern or a non-profit organization under 37 CFR 1.9.

I hereby declare that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful or false statements so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Further declarant sayeth not.

X Harald Rose

(Prof. Dr. Harald Rose)[a]

11/27/01

date

Note: All joint inventors must sign separate declarations. Where an independent inventor has signed granted conveyed or licensed or is under an obligation to do so to a small entity that small entity also must file the appropriate declaration

a) insert name of signatory inventor

b) delete inapplicable words

IN THE UNITED STATES PATENT & TRADEMARK OFFICE 056 C98

Applicant: Peter Schmid ET AL.

Name of Party in Interest:

Serial No: 10/018,904 Group Art Unit:

Filed: CONCURRENTLY HEREWITH Examiner:

For: ELECTRON-OPTICAL LENS ARRANGEMENT WITH AN AXIS THAT CAN BE LARGELY DISPLACED

CLAIM FOR SMALL ENTITY STATUS

37 CFR 1.9(c) - INDEPENDENT INVENTOR

I Peter Schmid (a), declare and say that:

1) I am ~~the sole~~(b)/a joint inventor(b) named in the above-identified application for Letters Patent.

2) I have not assigned, granted, conveyed, or licensed, and am under no obligation under contract or law to assign, grant, convey, or license, any rights in the invention to any person who could not likewise be classified as an independent inventor if that person had made the invention, or to any concern which would not qualify as a small business concern or a non-profit organization under 37 CFR 1.9.

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Further declarant sayeth not.

X Peter Schmid
(Peter Schmid) a)

11/27/01
date

Note: All joint inventors must sign separate declarations. Where an independent inventor has signed granted conveyed or licensed or is under an obligation to do so to a small entity that small entity also must file the appropriate declaration
a) insert name of signatory inventor
b) delete inapplicable words

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

056458

Applicant: Dr. Roland Janzen et al.

Name of Party in Interest:

Serial No: 10/018,904 Group Art Unit:

Filed: Concurrently Herewith Examiner:

For: ELECTRON-OPTICAL LENS ARRANGEMENT WITH AN AXIS THAT CAN BE LARGELY DISPLACED

CLAIM FOR SMALL ENTITY STATUS

37 CFR 1.9(c) - INDEPENDENT INVENTOR

I Dr. Roland Janzen(a), declare and say that:

1) I am the sole(b)/a joint inventor(b) named in the above-identified application for Letters Patent.

2) I have not assigned, granted, conveyed, or licensed, and am under no obligation under contract or law to assign, grant, convey, or license, any rights in the invention to any person who could not likewise be classified as an independent inventor if that person had made the invention, or to any concern which would not qualify as a small business concern or a non-profit organization under 37 CFR 1.9.

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Further declarant sayeth not.

X Dr. Roland Janzen

(Dr. Roland Janzen) a)

1.12.2001

date

Note: All joint inventors must sign separate declarations. Where an independent inventor has signed granted conveyed or licensed or is under an obligation to do so to a small entity that small entity also must file the appropriate declaration
a) insert name of signatory inventor
b) delete inapplicable words